The production of Fischer Tropsch liquids and power through biomass gasification

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Various concepts to produce Fischer Tropsch liquids from biomass have been investigated. This paper reviews the technical feasibility and economics of BIG-FT (Biomass Integrated Gasification-Fischer Tropsch) processes in general, identifies most promising system configurations and identifies key R&D issues essential for the commercialisation of BIG-FT technology. The FT synthesis produces hydrocarbons of different length from a gas mixture of H_2 and CO. The large hydrocarbons can be hydrocracked to form mainly diesel of excellent quality. The fraction of short hydrocarbons is used in a combined cycle with the remainder of the syngas. Overall LHV energy efficiencies, calculated with the flowsheet modelling tool Aspen^{plus}, are 33-40% for atmospheric gasification systems and 42-50% for pressurised gasification systems. Investment costs of such systems are between MU$ 280-450, depending on system configuration. In the short term, production costs of FT liquids will be about US $16/GJ (98 $/bbl). In the longer term, with large-scale production and higher CO conversion and C_{5+} selectivity in the FT process, production costs of FT liquids could drop to US $ 9/GJ (55 $/bbl). Research should be aimed at the development of large-scale (pressurised) biomass gasification and special attention must be given to the gas cleaning section.

Objectives

In principle, numerous process configurations for the conversion of biomass to FT liquids are possible, e.g. depending on gasifier types, the FT process considered and gas cleaning process. A general scheme of the main process steps to convert biomass to FT liquids (and power) and possible different options is shown in Fig. 1

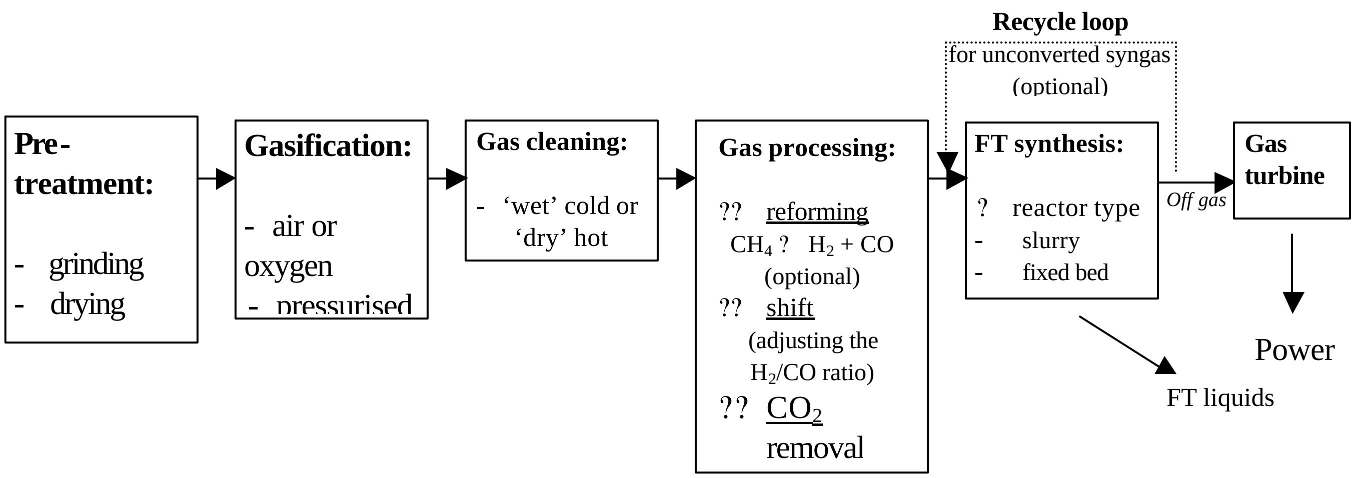

Fig. 1: A schematic view of converting biomass to FT liquids combined with a gas turbine

The main objective of this study is to evaluate the different options to use biomass for the production of FT liquids. The main research questions are:

?? To explore the technical feasibility and economics of BIG-FT processes in general, with specific attention for gas cleaning requirements

?? To identify most promising system configurations; various biomass gasification processes will be studied in combination with FT-concepts in two main categories:

1. Full conversion Fischer Tropsch with the possible use of a gas turbine, focussed on a maximum amount of FT liquids.
2. Once through Fischer Tropsch with co-firing of the off gas in a gas turbine.

?? To investigate economies of scale, the capacity considered of the BIG-FT systems is in the range of 100 to 1600 MWth, and the perspectives of this route on the longer term.
?? To identify key R&D issues essential for the commercialisation of BIG-FT technology.

Conclusions and recommendations
Pressurised gasification based systems have much better *overall energy efficiencies* (42-50% LHV) than atmospheric systems (33-40% LHV). This is mainly due too the high electricity consumption of the syngas compressors when atmospheric gasifiers are used.
Both the IGT and EP gasifier appear to be most suitable for BIG-FT systems. High CO conversion, either once through or after recycle, and high C_{5+} selectivity are important for a high overall energy efficiency.

In the *short term*, production costs of FT diesel, naphtha and kerosene could be about US $16/GJ. Investment costs have a share of 50% in overall production costs of FT liquids. The pre-treatment, gasification (with oxygen) and cold gas cleaning account for almost 75% of total capital costs. Biomass costs are 30% of total production costs (assuming a biomass price of US$ 2/GJ), O&M (almost proportionally to investment costs) 20%.
In the *longer term* with large-scale production, high C_{5+} selectivity, high CO conversion and technological learning, production costs of FT liquids could drop to US $9/GJ. Reduction of capital costs for a third generation plant, due too scaling up (minus 13%) and technological learning (minus 15%) have a strong impact on overall production costs. Biomass costs per GJ FT liquid will decrease due to an increase of overall energy efficiency. This is especially due to higher C_{5+} selectivity and higher (once through) CO conversion.
When diesel is the desired final product, the FT product requires *hydrocracking*. Besides 60% diesel, 40% naphtha and kerosene are produced. Hydrocracking will add about 5% to production costs. Conventional *production costs* of diesel are about US $0.14/liter or US $4/GJ. Production costs of 'green' FT diesel, naphtha and kerosene (US $16/GJ) are not competitive with conventional prices. In the longer term conventional prices could go up due too higher oil prices, but still 'green' FT liquids (US $9/GJ) are not competitive with expected diesel prices (US$ 5.5/GJ).

There are several uncertainties with respect to the *technology status*. A very critical step in the whole system is gas cleaning. It still has to be proven if the gas cleaning section is able to meet the strict cleaning requirements for FT synthesis. Possibly CO_2 removal by amine treating is required for cleaning purposes, thereby raising production costs. Pressurised (oxygen) gasification systems, having most promising economics and advantages of scale, still need further development. At present, only atmospheric air gasification systems, operating at relatively small scale, have proved to be reliable.

In the long term the efficiency of the concepts will be higher if high selectivity can be combined with high conversion. This could be realised in either fixed bed or slurry reactors. Costs for slurry reactors, which are not available yet, could be lower than for fixed bed reactors and will definitely have better economies of scale. Heat integration can also be improved. Power generation in the gas turbine will improve if used on large scale. Hot gas cleaning has high potential of improving efficiency, but the uncertainties about developments and costs of this promising option are substantial.